

## AMENDMENTS TO THE CLAIMS

1           1. (Currently amended) In a system in which a hardware target computer  
2 system, which has a target instruction set architecture (ISA), executes a target  
3 instruction sequence corresponding to a source instruction sequence of a source  
4 system, which has a source ISA and is running on the target computer system, a  
5 method for handling exceptions comprising the following steps:

6           converting the source instruction sequence into the target instruction sequence  
7 by binary translation, each instruction in the source instruction sequence being  
8 converted into a corresponding translated target instruction sequence, which may  
9 consist of a single target instruction;

10          determining beginning and ending addresses of each source instruction and  
11 each corresponding translated target instruction;

12          generating a mapping between the beginning and ending addresses of each  
13 source instruction and its corresponding translated target instruction sequence;

14          executing the translated target instruction sequence;

15          at any point in the translated target instruction sequence, sensing the presence  
16 of an exception and determining whether each sensed exception is synchronous or  
17 asynchronous, a synchronous exception being defined as an exception resulting from  
18 attempted execution of a target instruction and an asynchronous exception being  
19 defined as an exception resulting from an event unrelated to the execution of a target  
20 instruction; and

21          if the sensed exception is asynchronous, resuming to completion the execution of  
22 the target instruction sequence in binary translation from the point in the translated  
23 target instruction sequence at which the asynchronous exception was sensed before  
24 handling the asynchronous exception and thus delaying handling of each  
25 asynchronous sensed exception until, and no later than, completion of execution of the  
26 target instruction sequence corresponding to the current source instruction when the  
27 asynchronous exception is sensed.

2. (Canceled)

3. (Canceled)

4. (Canceled)

1        5. (Previously presented)    A method as in claim 1, in which synchronous  
2 exceptions are of either of two types, namely, transparent and non-transparent, a  
3 transparent exception being defined as an exception requiring processing action wholly  
4 within the target computer system, and a non-transparent exception being defined as an  
5 exception requiring processing that alters a visible state of the source system, further  
6 including the following steps:

7        determining whether the sensed synchronous exception is transparent or non-  
8 transparent;

9        handling each transparent synchronous exception externally from the source  
10 system, the visible state of the source system thereby remaining unaltered; and

11       forwarding to the source system for processing each non-transparent  
12 synchronous exception.

1       6. (Original)    A method as in claim 5, in which the step of forwarding each  
2 non-transparent synchronous exception to the source system includes the step of  
3 converting the sensed exception into a simulated source exception in a source  
4 instruction stream, which is sensed by and interrupts the source system.

7. (Canceled)

1           8. (Original)   A method as in claim 7, further including the following steps:  
2           determining a source instruction pointer as a predetermined function of the final  
3 target instruction pointer;  
4           forwarding and processing the sensed asynchronous exception;  
5           resuming execution at the location in the translation cache that corresponds to a  
6 current source instruction pointer; and  
7           asynchronous exceptions thereby being processed only upon completion of  
8 execution of the translated target instructions corresponding to whole source  
9 instructions.

1           9. (Original)   A method as in claim 8, in which the step of delaying processing  
2 of the sensed asynchronous exception further includes the step of simulating execution  
3 of the remaining target instructions.

1           10. (Original)   A method as in claim 8, in which the step of delaying processing  
2 of the sensed asynchronous exception further includes the step of single-stepping the  
3 execution of the remaining target instructions.

1           11. (Original)   A method as in claim 8, in which the step of delaying processing  
2 of the sensed asynchronous exception further includes the following steps:  
3           temporarily replacing with a trap generation instruction the initial target  
4 instructions in each of the translated target instruction sequences that correspond to  
5 target instruction sequences that possibly immediately follow the current target  
6 instruction sequence;  
7           resuming execution of the current target instruction sequence from the point at  
8 which the asynchronous exception was sensed;  
9           restoring each of the temporarily replaced instructions with their original content  
10 after completion of the processing of the sensed asynchronous exception; and  
11           upon reaching the trap generation instruction, forwarding and processing the  
12 sensed asynchronous exception.

1           12. (Original)   A method as in claim 8, in which the step of delaying the  
2   processing of the sensed asynchronous exception further includes the following steps:  
3           temporarily replacing with a trap generation instruction each indirect branch  
4   instruction, each indirect branch instruction corresponding to a possible last instruction  
5   of the current target instruction sequence;  
6           resuming execution of the current target instruction sequence from the point at  
7   which the asynchronous exception was processed;  
8           restoring each of the temporarily replaced instructions with their original content;  
9   and  
10          simulating the restored indirect branch instruction.

1           13. (Original)   A method as in claim 1, in which:  
2   the source system is a virtual machine;  
3   a virtual machine monitor that is operationally installed between the virtual  
4   machine and the hardware target computer system, the virtual machine thereby running  
5   on the virtual machine monitor;  
6   the steps of converting the source instruction sequence into the target instruction  
7   sequence by binary translation, executing the translated target instruction sequence,  
8   sensing the presence of an exception, and delaying application of the sensed exception,  
9   are carried out by the virtual machine monitor.

1           14. (Original)   A method as in claim 1, in which the source ISA is identical to  
2   the target ISA.

1           15. (Previously presented)   In a system in which a hardware target computer  
2   system, which has a target instruction set architecture (ISA), executes a target  
3   instruction sequence corresponding to a source instruction sequence of a source  
4   system, which has a source ISA and is running on the target computer system, a  
5   method for handling exceptions comprising the following steps:  
6           converting the source instruction sequence into the target instruction sequence  
7   by binary translation, each instruction in the source instruction sequence being  
8   converted into a corresponding translated target instruction sequence, which may  
9   consist of a single target instruction;  
10          executing the translated target instruction sequence;  
11          at any point in the translated target instruction sequence, sensing the presence  
12   of an exception,  
13           each exception being of either of two types -- synchronous and  
14   asynchronous -- a synchronous exception being defined as an exception resulting from  
15   attempted execution of a target instruction and an asynchronous exception is defined as  
16   an exception resulting from an event unrelated to the execution of a target instruction,  
17           synchronous exceptions being of either of two types, namely, transparent  
18   and non-transparent, a transparent exception being defined as an exception requiring  
19   processing action wholly within the target computer system, and a non-transparent  
20   exception being defined as an exception requiring processing that alters a visible state  
21   of the source system;  
22          determining whether each sensed exception is synchronous or asynchronous;  
23          determining whether each sensed synchronous exception is transparent or non-  
24   transparent;  
25          upon sensing the presence of an asynchronous exception during execution of a  
26   current one of the translated target instruction sequences, delaying processing of the  
27   sensed asynchronous exception until completion of the remaining target instructions in  
28   the current translated target instruction sequence;  
29          determining beginning and ending addresses of each source instruction and  
30   each corresponding translated target instruction;

31 generating a mapping between the beginning and ending addresses of each  
32 source instruction and its corresponding translated target instruction sequence;  
33 handling each transparent synchronous exception externally from the source  
34 system, the visible state of the source system thereby remaining unaltered;  
35 forwarding to the source system for processing each non-transparent  
36 synchronous exception;  
37 determining a source instruction pointer as a predetermined function of the final  
38 target instruction pointer;  
39 forwarding and processing each sensed asynchronous exception;  
40 resuming execution at the location in the translation cache that corresponds to a  
41 current source instruction pointer, that is, from the point in the translated target  
42 instruction sequence at which the asynchronous exception was sensed, asynchronous  
43 exceptions thereby being processed only upon completion of execution of the translated  
44 target instructions corresponding to whole source instructions;  
45 delaying handling of each asynchronous sensed exception until, and no later  
46 than, completion of execution of the target instruction sequence corresponding to the  
47 current source instruction when the asynchronous exception is sensed;  
48 in which:  
49 the source system is a virtual machine;  
50 a virtual machine monitor that is operationally installed between the virtual  
51 machine and the hardware target computer system, the virtual machine thereby running  
52 on the virtual machine monitor; and  
53 the steps of converting the source instruction sequence into the target instruction  
54 sequence by binary translation, executing the translated target instruction sequence,  
55 sensing the presence of an exception, and delaying application of the sensed exception,  
56 are carried out by the virtual machine monitor.

1           16. (Currently amended)   A system for virtualizing a computer system using  
2 binary translation comprising:  
3           a hardware target computer system that has a target instruction set architecture  
4 (ISA) and executes a target instruction sequence;  
5           a source system that has a source ISA and a source instruction sequence;  
6           an intermediate software layer forming an interface between the source system  
7 and the hardware target computer system;  
8           a binary translator included within the intermediate software layer and converting  
9 the source instruction sequence into the target instruction sequence by binary  
10 translation, each instruction in the source instruction sequence being converted into a  
11 corresponding translated target instruction sequence, which may consist of a single  
12 target instruction;  
13           an exception handler included within the intermediate software layer and, at any  
14 point in the translated target instruction sequence, sensing the presence of an exception  
15 and determining whether the exception is synchronous or asynchronous;  
16           a resume component within the intermediate software layer for resuming to  
17 completion the execution of the target instruction sequence in binary translation from  
18 the point in the translated target instruction sequence at which the asynchronous  
19 exception was sensed if the sensed exception is asynchronous, before handling of the  
20 asynchronous exception and  
21           the exception handler further delaying handling of each asynchronous sensed  
22 exception until, and no later than, completion of execution of the target instruction  
23 sequence corresponding to the current source instruction when the asynchronous  
24 exception is sensed.

1           17. (Previously presented)   A system as in claim 16, further including a map  
2 containing a mapping between beginning and ending addresses of each source  
3 instruction and its corresponding translated target instruction sequence.

1           18. (Previously presented)   A system as in claim 17, in which:  
2           each exception may be of either of two types -- synchronous and asynchronous --  
3           a synchronous exception being defined as an exception resulting from attempted  
4           execution of a target instruction and an asynchronous exception being defined as an  
5           exception resulting from an event unrelated to the execution of a target instruction; and  
6           the exception handler further determines whether each sensed exception is  
7           synchronous or asynchronous.

1           19. (Previously presented)   A system as in claim 18, in which:  
2           synchronous exceptions are of either of two types, namely, transparent and non-  
3           transparent, a transparent exception being defined as an exception requiring processing  
4           action wholly within the target computer system, and a non-transparent exception being  
5           defined as an exception requiring processing that alters a visible state of the source  
6           system; and  
7           the exception handler is further provided:  
8                 for determining whether the sensed synchronous exception is transparent  
9                 or non-transparent;  
10                for handling each transparent synchronous exception externally from the  
11                source system, the visible state of the source system thereby remaining unaltered; and  
12                for forwarding to the source system for processing each non-transparent  
13                synchronous exception.

1           20. (Previously presented)   A system as in claim 19, in which the exception  
2           handler is further provided for converting the sensed exception into a simulated source  
3           exception in a source instruction stream, which is sensed by and interrupts the source  
4           system.



1           21. (Previously presented) A system as in claim 19, in which the exception  
2 handler is further provided, upon sensing the presence of an asynchronous exception  
3 during execution of a current one of the translated target instruction sequences, for  
4 delaying processing of the sensed asynchronous exception until completion of the  
5 remaining target instructions in the current translated target instruction sequence.

1           22. (Previously presented) A system as in claim 19, in which the exception  
2 handler is further provided  
3           for determining a source instruction pointer as a predetermined function of the  
4 final target instruction pointer;  
5           for forwarding and processing the sensed asynchronous exception; and  
6           for resuming execution at the location in the translation cache that corresponds  
7 to a current source instruction pointer, asynchronous exceptions thereby being  
8 processed only upon completion of execution of the translated target instructions  
9 corresponding to whole source instructions.

1           23. (Previously presented) A system as in claim 16, in which:  
2           the source system is a virtual machine;  
3           the system further includes a virtual machine monitor that is operationally  
4 installed between the virtual machine and the hardware target computer system, the  
5 virtual machine thereby running on the virtual machine monitor; and  
6           the binary translator and exception handler are included within the virtual  
7 machine monitor.

1           24. (Original) A method as in claim 16, in which the source ISA is identical to  
2 the target ISA.